Preparing for Professionalism. How Engineering Students Experience the Role of Professional Engineers in Society

Abstract

Higher education institutions are considered important actors to secure and provide a professionalised workforce, and they play a pivotal role in the formation of a professional identity among their graduates. Technology professionals such as engineers are confronted with blurred boundaries between and within different disciplinary fields and a virtually ubiquitous role of technology in an increasingly globalised society facing challenges like resource depletion, poverty, climate change and economic crisis. Engineers are expected to take on environmental, techno-scientific and socio-technical roles and to add contextual skills to their scientific and technical competencies along with social responsibility. Two-point surveys to all Danish engineering students in the 2010 cohort during their first year of enrolment were deployed in order to investigate their views on the role of engineers in society. The results indicate that student experiences run counter to some of the intentions for their professional identity development.

PAPER

Introduction

Providing a professionalised workforce prepared to play a role in sustaining and developing society seems to be a particularly challenging task for engineering education institutions. Engineers are confronted with blurred boundaries between and within different disciplinary fields and a virtually ubiquitous role of technology in an increasingly globalised society facing a range of challenges. This article addresses ways in which Danish engineering students conceive of their future professional role in society in the first month and at the end of their freshman year.

Theoretical base

A range of societal challenges sometimes referred to as "grand challenges"[1] threaten the existence of present societies[2]. Jamison (2012) points to three challenges that specifically confront engineering and engineering education: An *environmental challenge* demanding a concern for environmental protection, resource exploitation and climate change, a *techno-scientific challenge* implying a new interplay of science, knowledge creation and technology blurring the traditional disciplinary boundaries and creating new demands on engineers and various *socio-technical challenges* resulting from the permeation of science and technology into all aspects of contemporary life, requiring engineers to behave in a socially responsible way. These challenges have been responded to by higher education systems in contradictory ways; on the one hand, engineers are expected to add commercial and entrepreneurial skills to their scientific and technological competence and, on the other hand, they are expected to contribute to the development of more sustainable and socially useful technologies, which calls for an environmental consciousness and sense of social responsibility as part of their professional engineering identity. However, it is difficult to meet these expectations in one professional identity. These demands lead to fears that engineering identity is at risk of disappearing or defragmenting into a myriad of separate professional identities.[3]

Methods

Nation-wide, longitudinal, two-point web-administered surveys reaching the full population of the engineering student year group 2010 in their first month and again after their first year of studies serve as sources of empirical data. The surveys were deployed as part of the PROCEED[4] in order to investigate Danish engineering student experiences and anticipations of their future professional identity.

Results

For an engineer to tackle societal challenges, contextual elements of professional problem solving such as societal and global context, ethics and contemporary issues are generally considered pivotal. Nonetheless, these four issues were among the items that fewest students selected among their five most important items practicing engineering out of 20 items in total. And the four issues were selected even more rarely at the end of the freshman year. See Appendix for Tables.

Three roles of engineers in society each emphasising one of the theoretically based challenges, are ranked in relative importance by the engineering students. The environmental role has risen in importance among the engineering students over their freshman year relatively to the other two choices, and in the second survey the largest share of the students selects this role as the *most important*. At the same time, environmental contribution is selected by the largest share of respondents as the *least important* role of engineers in society .This division of the respondents is caused by differences across engineering degree programmes (e.g. environmental engineering students emphasising the environmental role as opposed to students within internet, software and communication technology) and gender differences (female students tend to find the environmental role of engineers in society more important than men). The socio-technical contribution of engineers to ensuring fair and responsible use of technology development is particularly pertinent among those studying internet, software and communication technology. In relative measures, though, this role becomes less important to engineering students of all programme types except biotechnology during their freshman year. This may be due to the abstract aspects of this role relating to philosophy of science, often not a large part of engineering curriculum until later in the study.

Creating an overview of complex interrelations between different scientific and technical fields is ranked as *most important* by more students at the end of the year than at the beginning. At the same time, more students than initially come to rank it as the *least important* role. In particular, students of environmental engineering tend to consider this techno-scientific role least important. Women are less inclined than men to rank techno-science as the most important engineering role, and this gender difference increases during the first year. An initial emphasis of this role comes with a larger-than-average-decrease in likeliness to include societal context among the most important engineering items over the first year. Instead, this group becomes more inclined to select the general top scoring items problem solving and teamwork among their five important engineering issues.

The engineering students assess their progress during the freshman year within different areas relating to societal challenges. Students with different priorities of the three societal roles of engineers appear to progress differently. After a year there is statistically significant difference in their assessed progress in the fields of social responsibility, societal context and environmental and economic optimisation. Students emphasising the environmental role of engineering experience a higher progress in the latter two, whereas those initially prioritising the socio-technical responsibility of engineers also come to experience the highest progress in social responsibility during their freshman year. When it comes to progress in personal and interpersonal competencies there is no statistically significant difference between the groups.

Between 38 and 75% of the students find that they have undergone no or little progress in the following fields: understanding of the role of technology in society, responsible use of technology, social responsibility, sustainability, knowledge on energy minimization, environmental impact assessment and knowledge of economics. In comparison, 24% experience little or no progress in their teamwork skills. It seems there is room for additional advances of the engineering students in contextual learning to address societal challenges.

Conclusion

There is a large variation in Danish engineering students' views on professional engineering and its contribution to society; environmental, techno-scientific and socio-technical emphases co-exist in different mixes at different types of engineering programmes. Consideration for societal challenges is included in the conceptualisation of professional engineering identity only to a minor extent. When environment imbues the anticipated professional role at the commencement of their education, the students experience a larger progress in fields relating to societal challenges. In general, though, the development of engineering freshman attitudes seems to run counter to educational intentions of contextual broadness and inclusion of consideration for societal challenges into the nascent professional identity which suggests that this area may need further attention.

Limitations

The findings are based on engineering student during the freshman year. Though the tendencies detected, may suggest directions of the development of the respondents' professional identity at the time of their graduation, conclusions are limited to the first year's development. Further research is required to assess actual attitudes at a later point in time.

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[1] ABET 2006, ABET 2004, Christensen et al 2009, Jamison 2012, Jørgensen 2007, NAE 2005, RAE 2007, Sheppard et al 2009, Sheppard et al 2008.

[2] ABET 2006, ABET 2004, Atman et al 2010, Christensen et al 2009, Christensen et al 2006, Crawley et al 2007, Haase 2012a, Haase 2012b, Haase et al 2013, Jamison 2012, Jamison 1997, Jamison et al 2011, Kleinman 2005, NAE 2010, NAE 2008, NAE 2005, NAE 2003, RAE 2007, Sheppard et al 2009, Sheppard et al 2010, Solbrekke 2008, TA 2009.

[3] Bourg 2003, Buch 2012, Buch 2011, Christensen et al 2009, Jamison 2012, Jamison 2009, Jungert 2011, Jørgensen 2007, Knight 2011, Lehmann et al 2008, Loui 2005, Mann 2009, Reid 2008, Trede et al 2012, Williams 2002.

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Appendix

Table 1a Prioritisation of role of engineers in society

Role of engineers in society*, ranking of least to most important on a scale from 0 to 100		2010	2011
Problem solving related to climate change and environmental degradation	Mean: S.E.M:	44,9 7,1	49,9 8,2
Ensuring that technological development is utilised in a fair and responsible way	Mean: S.E.M:	54,7 7,0	49,8 7,5
Creating an overview of complex interrelations between different scientific and technical fields	Mean: S.E.M:	50,4 6,9	50,3 8,0
	N	3339	2666

Table 1b Prioritisation of role of engineers in society

Percentage selecting item as *most* important role of engineers in society*	2010	2011
Environment	29,4	35,7
Tech responsibility	38,1	32,5
Sci-tech overview	32,5	34,2
N	3339	2666

Table 1c Prioritisation of role of engineers in society

Percentage selecting item as *least* important role of engineers in society*	2010	2011
Environment	39,6	36,0
Tech responsibility	28,7	30,4
Sci-tech overview	31,8	33,6
N	3339	2666

* Question formulation: Prioritise between the statements below on the role of engineers in society. Please write 1 at the statement that you find most important, 2 at the second-most important statement and 3 at the third most important.
Engineers should contribute to solving problems related to climate change and environmental degradation. Engineers should contribute to ensuring that technological development is utilised in a fair and responsible way. Engineers should contribute to creating an overview of complex interrelations between different scientific and technical fields

Table 2a Selection of most important items practising engineering

Five most important items practising engineering	Percentage 2010	Percentage 2011
Ethics	7,0	5,2
Management skills	6,9	6,0
Contemporary items	9,2	6,4
Societal context	12,2	9,0
Global context	11,2	10,8
Design	13,0	12,5
Data analysis	14,5	13,8
Conducting experiments	10,7	14,5
Professionalism	19,6	17,7
Business knowledge	14,4	18,0
Leadership	18,5	18,9
Math	24,7	24,3
Science	26,0	25,5
Life-long learning	22,0	26,1
Communication	33,7	31,7
Engineering analysis	33,9	33,1
Engineering tools	32,2	34,0
Creativity	55,1	51,7
Teamwork	56,9	61,6
Problem solving	78,4	79,2
Total (five items selected)	500	500
N	3480	2945

Question formulation: Of the 20 items below, please put a check mark next to the FIVE you think are MOST IMPORTANT practising engineering.

Table 2b. Selection of most important items practising engineering by prioritised role of engineers in society at first survey deployment

Five most important items practising engineering, percentage	2010			2011		
	Environ-mental	Tech respon-sibility	Sci-tech	Environ-mental	Tech respon-sibility	Sci-tech
Problem solving	78,9	83,0	81,4	76,2	78,8	85,7
Teamwork	64,1	59,4	52,5	59,6	60,8	62,7
Creativity	51,0	61,5	54,2	55,0	50,5	55,7
Engineering tools	33,8	32,3	32,0	35,4	30,8	35,7
Engineering analysis	31,0	30,3	37,1	28,1	34,3	35,7
Communication	34,1	33,5	28,2	36,7	34,3	27,5
Life-long learning	21,7	23,3	25,1	29,6	23,8	27,5
Science	32,7	20,6	23,2	25,8	26,6	26,0
Math	23,6	23,8	22,4	25,6	23,1	25,0
Professionalism	17,2	17,1	20,3	13,9	19,7	15,8
Leadership	12,0	18,8	19,5	14,3	23,2	15,3
Business knowledge	11,7	16,9	15,1	15,6	16,0	17,5
Data analysis	14,6	12,5	17,2	12,6	14,8	14,7
Conducting experiments	12,0	7,2	10,4	14,1	11,2	13,6
Design	11,2	12,2	12,1	13,4	11,6	10,1
Global context	14,5	11,4	12,6	12,7	10,3	9,9
Societal context	12,9	11,8	15,0	9,9	10,1	7,6
Contemporary issues	10,2	10,4	7,7	8,8	6,7	5,4
Ethics	8,0	5,3	7,7	7,1	6,0	4,7
Management skills	4,8	8,9	6,4	5,5	7,5	3,9
Total (five items selected)	500	500	500	500	500	500
N	950	1108	927	872	1048	897

Only respondents responding to both questionnaires, weighted figures. Question formulation: Of the 20 items below, please put a check mark next to the FIVE you think are MOST IMPORTANT practising engineering.

Table 3a Self-assessed progress

Indications of progress within field, percentages, 2011	No or minor	Major	N
Knowledge of economics	74,5	7,5	2621
Environmental impact assessment	65,7	9,0	2595
Knowledge on energy minimization	61,1	13,2	2604
Sustainability	51,3	10,1	2504
Social responsibility	43,1	14,5	2583
Responsible use of technology	41,8	13,3	2438
Understanding of the role of technology in society	38,3	20,8	2617
Problem identification	25,7	21,6	2623
Teamwork skills	23,6	28,4	2675

Question formulation: Assess your progress within the following areas since you started your engineering programme. Response options: Major progress, Some progress, Minor progress, No progress, Do not know. Additional items are: Idea creation, Individual written assignments, Career planning, Conflict management, Laboratory experimenting, Oral communication, Organisational talent, Project management, Teamwork skills, Self-reflexivity, Ability to work independently, Written communication, Rote learning. Do not know-answers are treated as missing values.

Table 3b Self-assessed progress

Indexed scale ranging from 0-100		Interpersonal competencies[i]	Societal context[ii]	Personal competencies[iii]	Societal responsibility (single item)	Environmental & Economic Optimisation[iv]
Environ-ment	Mean:	55,8	54,4	51,1	48,2	37,2
	SEM:	0,7	0,9	0,7	1,1	0,9
	N:	749	718	784	814	805
Tech respon-sibility	Mean:	55,9	49,9	50,6	51,9	33,1
	SEM:	0,7	0,9	0,6	1,0	0,8
	N:	884	855	942	920	916
Sci-tech overview	Mean:	56,9	50,4	50,4	47,1	32,4
	SEM:	0,7	0,8	0,7	1,0	0,9
	N:	750	766	795	808	788

*) Index consisting of the items Conflict management, Oral communication, Organisational talent, Problem identification, Project management, Teamwork skills and Self-reflexivity, Cronbach's alpha reliability test =0.85
**) Index consisting of the items Responsible use of technology, Sustainability and Understanding of the role of technology in society, Cronbach's alpha reliability test =0.76
***) Index consisting of the items Individual written assignments, Career planning, Ability to work independently, Written communication and Rote learning, Cronbach's alpha reliability test =0.75
****) Index consisting of the items Environmental impact assessment, Knowledge on energy minimization and Knowledge of economics, Cronbach's alpha reliability test =0.72

Question formulation: Assess your progress within the following areas since you started your engineering programme. Response options: Major progress, Some progress, Minor progress, No progress, Do not know. Do not know-answers are treated as missing values.